Effects of Horse Riding on National Parks and Other Natural Ecosystems in Australia: Implications for Management

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Balancing increasing recreation demand with nature conservation objectives in Australia's protected areas provides a difficult challenge for land managers. This paper summarises the evidence of biophysical impacts of horse riding and highlights the important differences between Australian environments and those elsewhere. Unique environmental conditions in Australia make conservation lands in Australia potentially sensitive to the impacts of horses, both direct (e.g. trampling) and indirect (e.g. alteration of soil fungal regimes in response to addition of faeces and urine). We discuss ways in which horse use may be sustainably managed on Australian conservation estates, provided that certain conditions are met.

Introduction

In providing for the 'outdoor experience', horse riding takes place in a number of natural settings around Australia. These range from mountain and alpine environments to eucalypt forests and coastal sand dunes (Plates 1 and 2). Riding usually occurs on tracks and specifically designated bridle trails but in some coastal and montane areas free-range riding occurs. Horse parties vary in size from a few individuals to groups of up to 30 people. Organised groups are often part of a tour operation that may take place over several days and involve overnight camping.

One of the main problems facing policy makers and managers of national parks in Australia is the need to protect flora, fauna and representative ecosystems while providing for a variety of recreational uses. Providing recreational opportunities compatible with environmental protection is fundamental to park management and is especially significant when preservation of a natural area is the primary park objective. Horse riding has become a significant issue in some protected areas, as it forms part of the spectrum of recreational activities that occur in conservation reserves and national parks in Australia. This is particularly so where 'new' areas of conservation estate are declared over lands that have been historically used for grazing stock and herding them from horseback.

This paper therefore seeks to explore the appropriateness of horse riding in

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Plate 1 Beach riding, D'Entrecasteaux National Park, Western Australia

Plate 2 Horses crossing vegetated dunes, D'Entrecasteaux National Park, Western Australia

Australian protected areas that are also used for the purposes of ecotourism. It also summarises the evidence for biophysical impact and attempts to explore the wider environmental context of horses in Australia. The implications of these findings are then considered from a management perspective.

How Does Horse Riding in Natural Areas Equate with Ecotourism?

Beeton (1999a, b) provides a useful background as to the 'ecotourism' context of horse riding in Australia. She notes that horses were important in the early development of Australia. They were also used in sporting activities and out of this, horse riding has become an important recreational activity. The vision of the early stockman on horseback who grappled with adverse conditions and danger has become part of the Australian bush image and this is now marketed internationally with potential visitors sold the opportunity to become part of the legend (Beeton, 1999b). According to Beeton (1999a), horseback tourism has become part of the Australian bush image with the horse seen as being an integral part of the Australian landscape.

The increasing popularity and demand for horse riding has led to the development of commercial horse-back tours comprising short guided trail rides lasting one hour or so, to much longer trips to more remote locations (Beeton, 1999a). These latter tours often take place in national parks and other natural environments and involve camping. Beeton (1999a) maintains that such trips are also social occasions and result in riders interacting more with the environment. Moreover, people participating in the tour can recreate the rural image of the 'Australian bushman'.

The question is then raised 'is this ecotourism?'. If ecotourism is defined as embracing the study, admiration or appreciation of scenery and wildlife, as Blamey (1995) suggests, then horse riding could be placed within such a framework. The justification for this is that it is feasible to achieve this on horseback. If we go to other definitions then it is more difficult (see later discussion) to place horse riding under the umbrella of ecotourism. Dowling and Charters (2000), for example, consider ecotourism to be an educative and conservation-supporting practice. Many conservationists are against horse riding (see Beeton 1999a, b) and a distinct conservation-supporting attitude from horse-riding groups remains to be demonstrated. Both Coate (2001) and Newsome *et al*. (2002) define ecotourism as focusing on plants and animals in natural environments in an ecologically sustainable way. This also implies that there is minimal impact on the environment. This, as the following discussion explores, is the most difficult aspect of the ecotourism spectrum for horse riders to achieve in Australia.

The Problem

A number of North American studies provide a useful database on the environmental impacts of horse riding. These and the less-researched Australian situation have recently been summarised and reviewed by Landsberg *et al.* (2001), Phillips (2000) and Phillips and Newsome (in press). Impacts generally consist of damage to vegetation, increased trail depth and width, soil compaction, soil erosion and the introduction of weed species (Table 1).

Australian and North American studies have also shown that, because of

Table 1 Environmental impacts of recreational horse riding

Impact	*Salient Components of the North American Data Base*	*Salient Components of the Australian Data Base*
User conflicts in multiple-use areas	Watson *et al.* (1993) Shew *et al.* (1986) Absher and Absher (1979) Lee and Trahan (1975)	Beeton (1999a and b) Ramsay (1996)
Loss of vegetation height and cover	Cole and Spildie (1998) Weaver and Dale (1978) Dale and Weaver (1974)	Phillips and Newsome (in press) Phillips (2000) Whinam *et al.* (1994) Bolwell (1990) Gillieson *et al.* (1987)
Change in plant species composition	Weaver *et al.* (1979) Dale and Weaver (1974)	Phillips and Newsome (in press) Phillips (2000) Bolwell (1990)
Degradation of existing trail networks	Deluca *et al.* (1998) Wilson and Seney (1994) Summer (1986) McQuaid-Cook (1978) Weaver and Dale (1978) Dale and Weaver (1974)	Whinam and Comfort (1996) Harris (1993) Gillieson *et al.* (1987) Royce (1983)
Introduction of weeds	Marion *et al.* (1986) Cole (1983) Dale and Weaver (1974)	Weaver and Adams (1996) Whinam and Comfort (1996) Whinam *et al.* (1994) St John-Sweeting and Morris (1991) Royce (1983)
Accidental transport of fungal pathogens	McQuaid-Cook (1978)	Phillips and Newsome (in press) Phillips (2000) Royce (1983)
Loss of vegetation and soil degradation as a result of tethering	Cole and Spildie (1998) Olson-Rutz *et al.* (1996)	Phillips (2000)

increased visitation to reserved areas and the public requirement for a diversity of recreational experiences, user conflicts have arisen. In a North American survey carried out by Shew *et al.* (1986), 75% of all managers surveyed had received complaints about horses. Complaints most frequently consisted of manure on trails, campsite damage, trail wear and erosion, litter and damage to meadows and riparian vegetation. Insects associated with manure and urine, the sight of horses, tethering yards and fences, noise and safety issues are also recognised as additional social management problems that influence visitor experiences and create potential user conflict (Downie, 1997; Hammitt & Cole, 1998; Lee & Trahan, 1975; McClaran & Cole, 1993).

Most research and analysis into the attitudes of different user groups suggests that walkers/hikers have negative attitudes towards horse-riding groups

(Beeton, 1999b). Surveys carried out in the Sierra National Forest, California, USA revealed that while 4% of horse riders disapproved of meeting hikers, some 36% of hikers did not like encounters with horses (Watson *et al*., 1993). Many of the people who complain about horse users suggest that horse use and its associated impacts are not appropriate for wilderness and other natural areas and that the managing agency should take some action to eliminate it or reduce its impacts (Watson *et al*., 1993). In the USA, a social survey in Sierra Nevada showed that less than 15% of hikers surveyed approved of horses as a means of recreation travel (Absher & Absher, 1979). In Australia, a New South Wales national park's survey showed that more than 60% of park visitors rated recreational horse riding as undesirable (Ramsay, 1996).

Conflict between horse users and other recreationists has implications for visitor satisfaction. It is also possible that more environmentally sensitive and conservation-minded visitors are or will be discouraged from visiting certain areas or parks. Visitor and public confidence in land managers may also decrease if they perceive that the land management agency is allowing incompatible activities on the conservation estate. As park management and conservation are dependent on public cooperation, it is important to reduce user conflict so that visitors who want to appreciate natural values can enjoy their outdoor experience. It is, however, arguable that biophysical impacts pose the greatest problem for managers trying to protect biodiversity.

The problem lies in the fragility and low resilience of many Australian ecosystems. Australia is different from many other parts of the world in the lack of large herbivores. Moreover, many ecosystems in Australia exist under naturally 'stressful' conditions owing to extensive natural aridity and nutrient poverty. An important question to consider is to what extent these factors contribute to the significance of horse-riding impacts in Australian ecosystems?

The biophysical impacts of horse riding in protected areas and national parks: The database from Australia

Only a few researchers have carried out specific studies pertaining to Australian conditions (Table 1). Gillieson *et al.* (1987) investigated the impacts of horse riding at Gurragorambla Creek in Kosciusko National Park in New South Wales (Figure 1). Their results showed that even low-intensity horse use over undisturbed vegetation resulted in significant damage. Dyring's (1990) study in Kosciusko National Park and Bolwell's (1990) study in Alpine National Park, Victoria, also found that low levels of horse trampling can cause a significant reduction in vegetation height with fewer plant species being found on trampled sites. The invasion of exotic species was also prominent where native species had been trampled (Dyring, 1990).

Ramsay's (1996) survey for New South Wales National Parks and Wildlife Service showed that weed management was mentioned as a problem by over 80% of staff. Horses are often perceived as a vector for the introduction and dispersal of exotic plants in conservation reserves (Weaver & Adams, 1996). In South Australia, St John-Sweeting and Morris (1991) researched the fate of seeds that pass through the digestive tract of horses. The majority of seeds tested showed little or no loss in viability after transmission. The work showed that horses can disperse weed seeds for ten days after ingestion and pass relatively

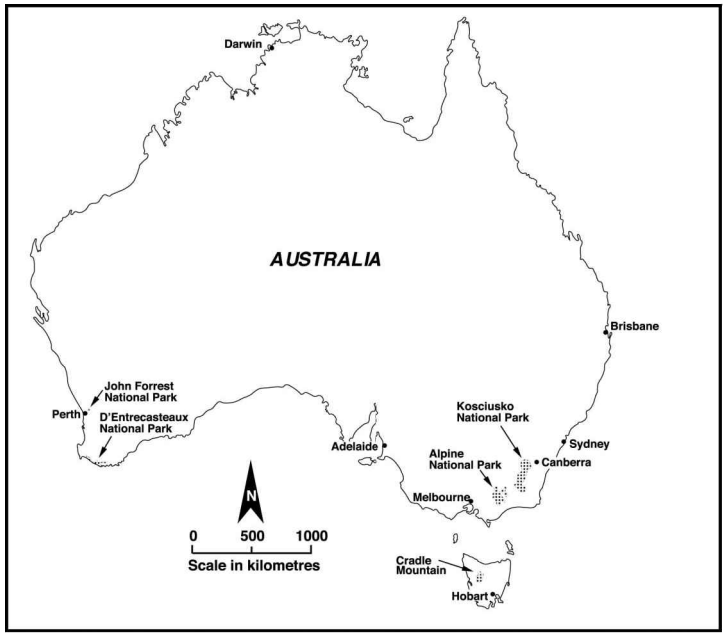

Figure 1 Location of national parks where horse-riding studies have been carried out in Australia

great amounts of seed four days after ingestion. In relation to this, experimental work by Whinam *et al.* (1994) showed that weed establishment was limited to manured plots. The highest mean number of weeds in manure was also found where grazing of native animals was excluded and in plots where the soil had been disturbed. Although their results showed that weed seeds are viable in horse manure, they were uncertain as to the extent weeds would eventually colonise away from the manure, which offers protection against frost and also enriches the underlying soil with nutrients.

Whinam and Comfort's (1996) study on horse impact on sub-alpine environments at Cradle Mountain, Tasmania (Figure 1), showed no indication of introduced weeds during the course of monitoring. The apparent absence of weeds on horse tracks was thought to be due to the constant churning of manure on the track, inhibiting the actual or visible establishment of weeds. This, coupled with marsupial grazing, has been shown to reduce seedling establishment from manure.

Royce (1983), on the other hand, observed that weed invasion and root-rotting fungus infected plants were significantly associated with horse-riding activity in John Forrest National Park in Western Australia (Figure 1). He also reported on soil degradation problems and found that the floristic health of vegetation to be notably lower along the sides of popular horse-riding trails in the park.

Soil loss and soil compaction are common impacts on horse trails in alpine and sub-alpine vegetation in Australia (Bolwell, 1990; Department of Conservation and Environment, 1991; Dyring, 1990; Gillieson *et al.*, 1987). Gillieson *et al.* (1987) found that as much as 16 cm of trail depth could be lost from established horse

trails in alpine areas. Department of Conservation and Environment (1991) studies in the Alpine National Park, Victoria, showed that horse use over two riding seasons resulted in an increase in trail depth of 5.6 cm. The results also indicated that trail width was less significant than trail depth (Department of Conservation and Environment, 1991; Harris, 1993). Dyring's (1990) study in Kosciusko National Park showed that as few as 20–50 horse passes resulted in an increase in compaction on dry loamy soils.

Whinam *et al.* (1994) found that the soils and vegetation of alpine shrublands were more susceptible to damage than grassland sites. *Grevillea australis* and most herb species were particularly vulnerable to damage from hooves, with most damage occurring at very low-use (30 passes) intensities. The full extent of the damage was not evident until a few months after the passage of horses. The study also showed that both fen and the bolster heath in the mountain environment exhibited marked impacts from minor levels of trampling. At the same time, Whinam *et al.* (1994) found that the soil and vegetation on well-drained uneroded grassland sites suffered relatively little impact even at increased levels of single-event trampling. Gillieson *et al.* (1987), nevertheless, have suggested that prolonged use at increased levels in the Kosciusko National Park results in significant damage to vegetation.

Phillips (2000) and Phillips and Newsome (in press) quantified the environmental impacts of horse riding at three untracked sites in D'Entrecasteaux National Park in Western Australia (Figure 1). Measurements of relative frequency of plant species, percentage vegetation cover, vegetation height and soil depth were taken from experimental transects using a point intercept frame. Using trampling intensities of 0, 20, 100, 200 and 300 passes, Phillips (2000) found that horse riding changed the relative frequency of plant species by causing a decline in the native herbaceous plants *Loxocarya cinerea*, *Orthosanthus laxus* and *Opercularia hispidula* (Figure 2). At the same time the percentage of bare ground increased from 5.2% at 0 passes to 31% following 300 passes (Figure 2). There was also a rapid reduction in percentage vegetation cover following 20 and then 100 passes (Figure 3). For example, at study site DE3 the vegetation cover decreased from 144.7% to 60.7%, a change of 84% between 0 and 300 horse passes. The greatest amount of decrease in vegetation cover was 34% between 20 and 100 horse passes with the most significant rate of decrease (15.4%) in the percentage of vegetation cover occurring between 0 and 20 horse passes.

Loss of vegetation height was even more marked with the vegetation decreasing from 201.5 mm to 81.4 mm at study site DE3, a change of 120.1 mm between 0–200 horse passes (Figure 4). The greatest amount of change being a decrease of 56.5 mm occurring between 0 and 20 passes.

The change in the soil depth from baseline micro-topography showed that as horse-trampling intensity increased, the soil depth decreased (Figure 5). At study site DE3, for example, the soil depth decreased 24.8 mm between 0 and 300 horse passes. The greatest degree of decrease in the soil depth was 10.5 mm between 20 and 100 horse passes. The most significant rate of decrease in soil depth (8.1 mm) occurred after 20 horse passes. Overall, the rate of decrease in the soil depth, although progressive, declined as horse trampling intensity increased.

These results clearly demonstrate that horse riding has the capacity to signifi-

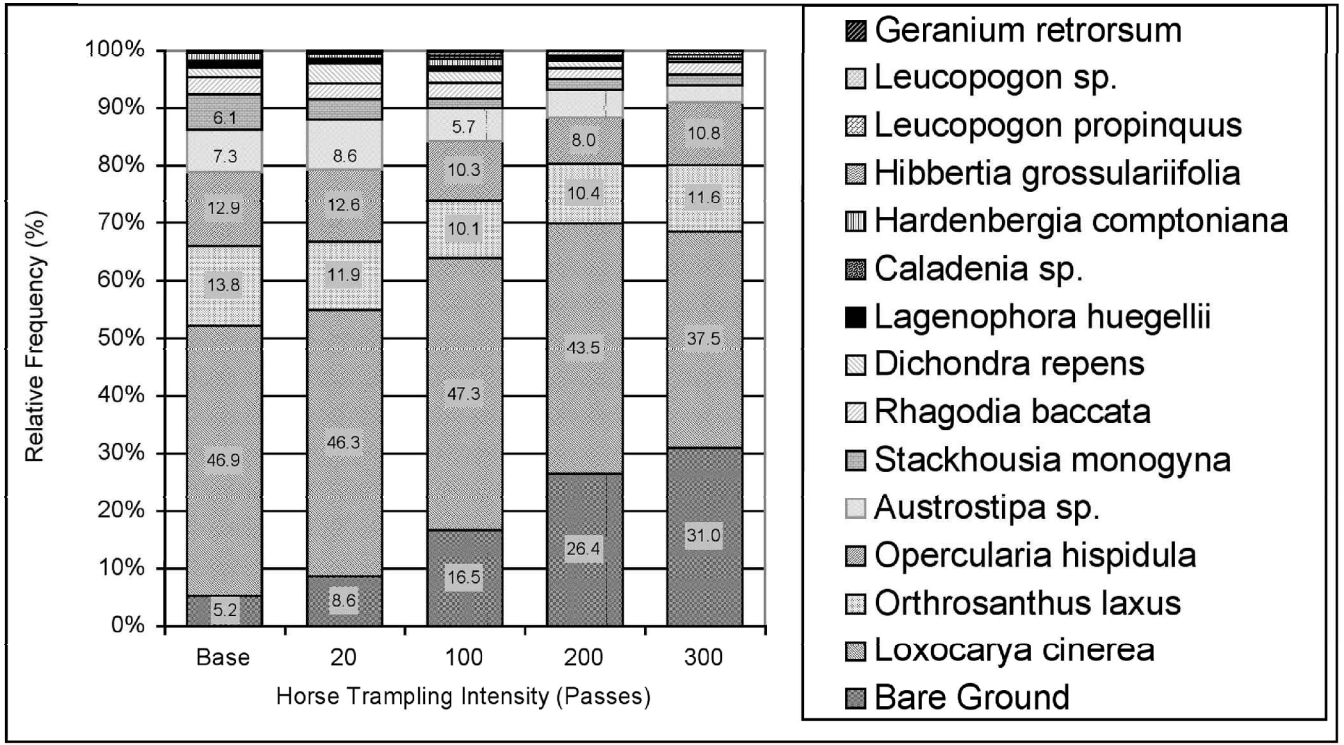

Figure 2 Relative frequency of plant species and bare ground after various intensitites of horse tranmpling at study site DE 3 in D'Entrecasteaux National Park, Western Australia

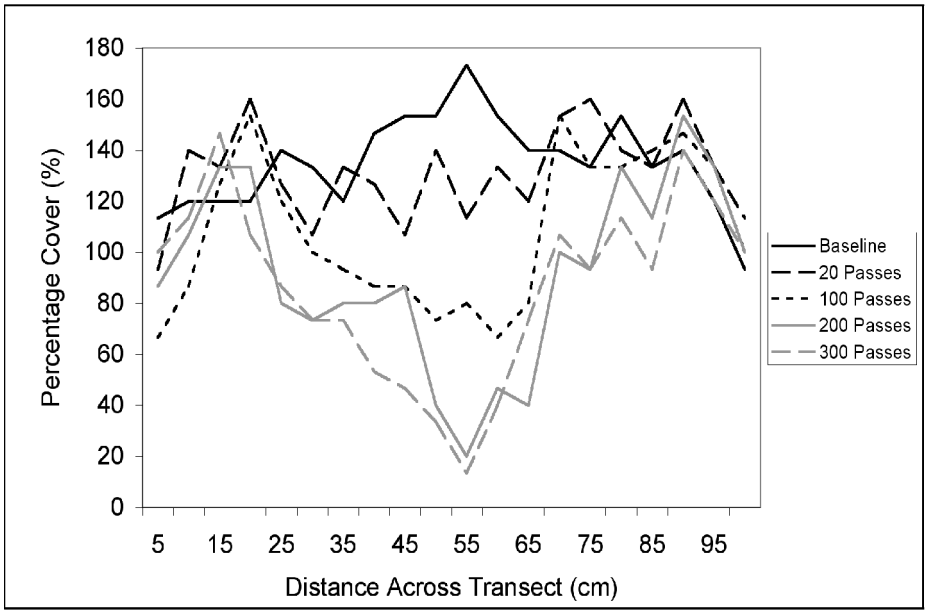

Figure 3 Percentage of overlapping vegetation cover across 5–100 cm of the treatment transects cross-sectional profile after various intensities of horse trampling at study site DE3 in D'Entrecasteaux National Park, Western Australia

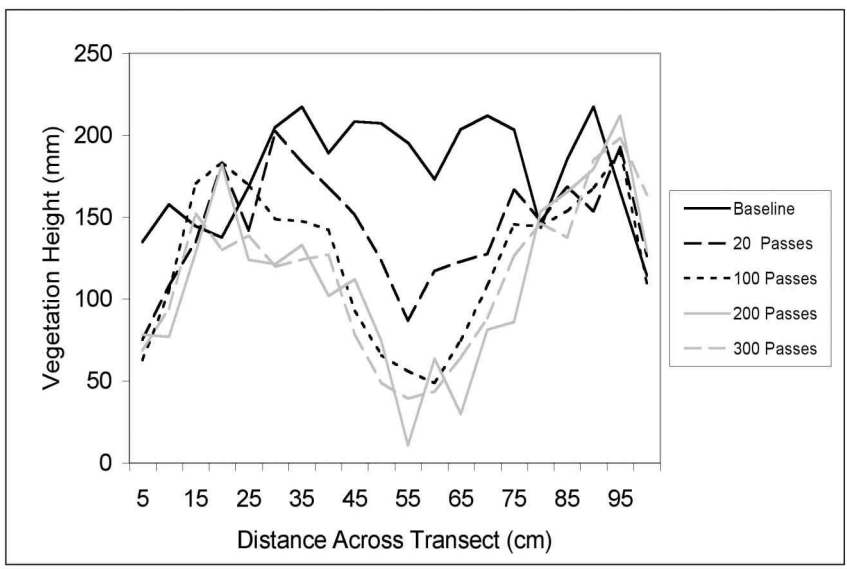

Figure 4 Vegetation height across 5–100 cm of the treatment transects cross-sectional profile after various intensities of horse trampling at study site DE3 in D'Entrecasteaux National Park, Western Australia

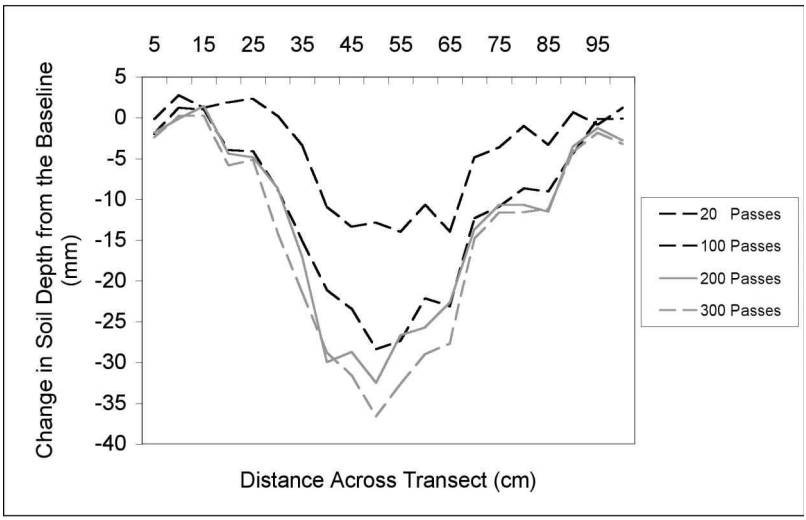

Figure 5 The change in soil depth from the baseline micro-topography across 5–100 cm of the treatment transects cross-sectional profile after various intensities of horse trampling at study site DE3 in d'Entrecasteaux National Park, Western Australia

cantly alter vegetation and soil conditions in untracked areas (Plate 3). Furthermore, in addition to the vegetation and soil impacts caused by trampling, Phillips (2000) noted that grazing is an additional impact associated with horse use at tethering areas (Plate 4). Horses temporary tied to bushes and trees, or man-made facilities, graze and trample surrounding vegetation, increase the area of exposed soil and loosen the soil surface, damage trees by exposing roots, as well as directly ripping out small bushes and trees to which they are tied. Tethering areas are of particular concern to national park management when the impacts become visually extensive (Annear, personal observation). Moreover, campsites used by horse parties intensify recreational impacts through additional trampling of vegetation, removal of coarse woody debris for firewood, loss of organic soil horizons, exposure of bare ground, soil compaction, littering, polluting ground water by human or horse waste and increased risk of wildfire and the spread of fungal diseases (CALM, 1987; Newsome *et al.* 2002).

The available data from Australia shows that many impacts mirror those that have been reported from the USA. There are, however, some important differences between the USA and Australia. First, Australia has no large native herbivores that have co-evolved with the present flora. Second, the Australian continent is characterised by the widespread occurrence of nutrient-poor soils and third, the presence of an introduced root-rot fungus (*Phytophthora cinnamomi*), and other plant diseases, is a pivotal issue in the maintenance of biodiversity in Australian National Parks (Podger *et al.*, 1996; Shearer & Tippett, 1989; Wills & Robinson, 1994). This is particularly so in Western Australia which is a global biodiversity hotspot (Bridgewater & Edgar, 1994). Because of these

Plate 3 Loss of vegetation height and cover following 300 horse passes at study site DE1, Entrecasteaux National Park, Western Australia

important differences, it is vital to consider these aspects as additional factors in understanding the environmental impacts of horse riding in Australian protected areas.

The presence of horses in Australian ecosystems: biogeographical and environmental considerations

Large herbivores have never been a major component of Australian ecosystems

There is, and always has been, a relative lack of native large herbivores in Australia. Moreover, horses (equids) have always been absent from the whole of Australasia, despite being widespread in the Old World today, and widespread in North and South America as recently as 10,000 years ago. Also absent were all other herbivorous mammals larger than gazelle size. Australia is also unique

Plate 4 Horse tethering site, D'Entrecasteaux National Park, Western Australia

among the continents, in that it has no extant native mammal of adult female body mass > 40 kg. The largest herbivores extant on the other continents (adult female body mass) are, Africa: elephant 3500 kg, Eurasia: elephant 3000 kg, North America: bison 600 kg, South America: tapir 300 kg (Nowak, 1991; Owen-Smith, 1988). Thus, even South America differs from Australia by an order of magnitude in the body mass of its largest extant native herbivore. Certain breeds of the domestic horse (*Equus caballus*) exceed one tonne. The largest equids are therefore nearly as massive as the largest animal (*Diprotodon*) ever found in Australia (Murray, 1991).

The extinct 'megafauna' of Australia has been inadvertently exaggerated. The largest extinct animal recorded in Cainozoic Australia (*Diprotodon optatum*) was only one tonne, an order of magnitude smaller than the largest known mammals on other continents. In addition, *D. optatum* and other megafauna (all of which were under one tonne, and many less than 500 kg), became extinct so long ago that they are possibly irrelevant to modern ecosystems in Australia. The megafaunal extinctions in Australia (most recent estimate 46,000 years ago) predated those in Eurasia and the Americas (10,000 years ago) and Madagascar (500 years ago), (Preston-Mafham, 1991; Roberts *et al*., 2001). Furthermore, the largest species in Australia were apparently restricted to relatively nutrient-rich landforms (arid central Australia, with minimal leaching; basalt in mesic coastal Australia), and there is no evidence that any animal over 500 kg ever inhabited the entire southwestern part of Australia, which has extremely flat and nutrient-poor substrates (Murray, 1991).

Perhaps the most graphic illustration of the lack of herbivores in Australia emerges from comparison with certain islands. Sulawesi is located between Asia and Australia, but has never been connected to either continent, or to any other islands (van Oosterzee, 1997). Despite being comparable to Tasmania in extent, Sulawesi has supported a relatively great number of herbivores that managed to reach it by swimming or rafting. At least two species of proboscideans occurred in the Pleistocene; to this day Sulawesi supports four species larger than kangaroos: two species of bovids (> 100 kg) and two species of pigs (> 40 kg). It also supports the largest of the phalangers (*Ailurops*, 10 kg), a herbivorous arboreal marsupial exceeding its relatives in Australia and New Guinea, and rivalling the koala (*Phascolarctos*) in body mass (Nowak, 1991).

Although the lack of large herbivores, and the relatively small impact of all herbivores, in Australia is presently unexplained (see Milewski & Diamond, 2000), it cannot be ignored in terms of management and conservation of vegetation. From an ecological perspective the successful introduction of domestic ungulates to Australia does not necessarily indicate that there was an empty niche for herbivores on this continent. Moreover, there has been widespread and severe degradation of vegetation as a result of pastoralism in Australia, and the survival of herbivore species in a feral state is possibly the result of access to artificial sources of supplementary micronutrients, in the form of bore water (Milewski, 2000; Milewski & Diamond, 2000). Where the carrying capacity of vegetation has been maintained for more than a century, this has generally necessitated a partial replacement of native taxa of grasses by introduced taxa (characteristically lawn-forming species) resilient to grazing, trampling, and eutrophication caused by introduced herbivores.

The significance of trampling in environments characterised by nutrient-deficient soils

The evolution of highly weathered laterite profiles and the occurrence of sandy parent materials has resulted in the development of nutrient-poor soils over large parts of Australia. This nutrient poverty, coupled with the prevalence of a desiccating atmosphere, has resulted in a flora highly adapted to low nutrient conditions and seasonal drought (Specht & Specht, 1999).

Plant survival strategies to cope especially with nutrient poverty include reduced leaves, insectivory, hemi-parasitism, root-nodulation with nitrogen-fixing bacteria, proteoid root mats, mycorrhizal associations and the development of lignified tissues. The development of hard, woody plant stems makes many plants susceptible to breakage as a result of trampling (Liddle, 1997).

Many Australian plant communities obtain additional nitrogen and phosphorus through ectomycorrhizal/proteoid root mats. Tommerup and Bougher (2000) report that the resilience of eucalypt woodland ecosystems is strongly linked to the presence of ectomycorrhizal fungi. The fungi help to acquire scarce nutrients, bind soil together and provide a source of energy for soil microbiota, invertebrates and small mammals. They assert that these important plant root-fungal associations are susceptible to disturbance, especially from trampling which breaks up the soil and disrupts the fungal mycelial network. Any decline in the fungi translates into a reduction in the health and vigour of associated trees and shrubs because of a reduced supply of nutrients to the plant.

The impact of weeds and introduced pathogens on Australian ecosystems

The presence of invasive weeds is linked to soil disturbance and soil nutrient enrichment (Hobbs & Atkins, 1998). The establishment and proliferation of weeds prevents native species from germinating and the ensuing competition for resources usually results in the displacement and gradual degradation of natural plant communities. For example, Yates *et al.* (2000) recognise this as a serious problem for the conservation of native species diversity in Western Australian temperate eucalypt woodlands. Weed invasion is a widespread problem in many protected areas. Management, therefore, requires substantial resources to operate effective weed control programmes.

Introduced pathogens, such as the root-rotting fungus *Phytophthora cinnamomi*, however, constitute an even more significant threat to biodiversity in Australia. *Phytophthora cinnamomi* causes dieback (death of uppermost branches and eventually the whole plant) of the dominant or common trees and shrubs in native vegetation in Australia. In Western Australia some 2000 plant species are susceptible to dieback. Wills and Keighery (1994) estimate that 92% of the Proteaceae are sensitive to root-rotting fungal infection. This plant family constitutes much of the biomass and diversity, and some keystone elements, in Western Australian heaths and eucalypt forest/woodland understoreys. Widespread dieback alters community structure and composition and poses a serious threat to rare and endemic plants in Western Australia. Root-rotting fungus can be spread by soil movement, and vehicle tyres, bicycles and walking boots are now recognised as carriers of the fungus. National and internationally important wildflower tourism resources in Western Australia are currently under threat

from the accidental spread of root-rotting fungus (Wills & Robinson, 1994). The presence of dieback is difficult to manage and strategies to minimise spread, such as identification and management of protectable areas currently free of the disease, quarantine, hygiene and public education, remain the main approaches to containing the disease at present.

The potential for recreational horse riding to degrade natural ecosystems in Australia

Trampling by hoofed animals causes a loss of surface litter, lichens and mosses and can compact the soil. These changes to the natural soil condition can reduce the infiltration of water and result in soil erosion (Yates *et al.*, 2000). Experimental work undertaken by Phillips (2000) and Phillips and Newsome (in press) has demonstrated that horses disrupt surface conditions and increase the proportion of bare ground (Figure 2). More significantly their work has shown that horses can move soil, as evidenced by changes in the microtopography of experimental transects (Figure 5). Resultant soil disturbance creates conditions suitable for the invasion of weeds and soil movement promotes the possibility of transferring *Phytophthora cinnamomi* and associated root pathogens from infected to non-infected areas.

Two further features make Australian ecosystems vulnerable to trampling impacts by horses. The first is that the soil surface of heath, banksia woodland, and all types of vegetation dominated by eucalyptus has evolved largely undisturbed by mammals (apart from minor excavations by small mammals such as bandicoots, e.g. *Isoodon obesulus*). The second is the demonstrated impact of horse riding relative to other recreational uses such as walking and the use of bicycles (Newsome *et al.*, 2002).

Because of drought and nutrient poverty, the growth of many understorey species tends to be slow. In addition to this, the brittleness of ligneous tissues in many Australian plants increases their susceptibility to trampling. These characteristics confer a low resistance to trampling impact.

According to Begon *et al.* (1996), resistance is the ability of a plant community to avoid being displaced. It would seem from the available evidence and discussion presented here that those Australian plant communities characterised by the development of a high degree of lignified tissue are susceptible to damage. The low resistance of eucalypt woodlands, the least resistant of some 14 different vegetation types that were measured, is evident from data compiled by Liddle (1997). Accordingly, it takes only 12 passes to reduce the vegetation of a eucalypt woodland by 50% as compared to 1412 passes to reduce the vegetation of an Australian sub-tropical grassland by 50%.

Resilience, on the other hand, is the speed of recovery following a disturbance (Begon *et al.*, 1996). We maintain here that the resilience of many Australian ecosystems is likely to be low because of nutrient-poor soils and a predominant desiccating climate, and because of the presence of diverse/complex ecosystems that are susceptible to infection by introduced pathogens.

At the same time, public appreciation of these problems can be obscured by the fact that the impact of plant disease is often very slow and can happen over one or two (human) generations. This incremental change can often go unnoticed, particularly if there is an absence of baseline data against which to

measure. Evidence of this is the species composition of much of the heath vegetation in D'Entrecasteaux National Park in Western Australia (Figure 1) that has lost most of the Proteaceae due to *Phytophthora cinnamomi* infection. This permanent change in species composition and ecosystem structure is evidence of low resilience.

There is a lack of environmental assessment and baseline monitoring in many places for planning recreational activity and measuring change. It is of critical importance that baseline conditions are recorded before potentially damaging recreational activities, such as horse riding, are allowed to operate.

Implications for the Management of Recreational Horse Riding in Australian National Parks and Other Protected Areas

National park and nature-based recreation managers throughout the world have recognised that where recreational activity takes place some level of impact is inevitable, and that decisions have to be made with regard to how much change is acceptable to users and managers (Hendee *et al*., 1990). Although legislation and agency policy provide a broad framework for the management of recreational activities in conservation reserves, good environmental planning and management requires biophysical and social research in the formulation of these decisions or judgements (Shew *et al*., 1986). Research can describe the social and ecological consequences of alternative horse-use levels, thus providing the opportunity for managers to judge whether these consequences are consistent with the area's management objectives (Hendee *et al*., 1990).

The general lack of quantitative data regarding the environmental impacts of horse riding in national parks and other recreation reserves in Australia has meant that research has played an insignificant role in helping to formulate recreation management plans. At the same time, one of the key issues is management capacity. This is because although managers can set various conditions and rules for horse riding, or other activities, the management capacity is generally not available to properly monitor or enforce these conditions. Our experience is that self-regulating systems usually fail. Even if most people observe the codes of conduct put in place, a small number will choose to ignore them. Without the appropriate level of management the total system then often fails, especially with activities such as horse riding, where relatively low levels of inappropriate activity can cause significant impact.

The acceptability of various management options

Prohibit use

The simplest, most effective means of minimising horse riding impact is to prohibit all use. Accordingly, Royce (1983) concluded that horse riding had seriously degraded the environmental quality of large areas of John Forrest National Park in Western Australia and recommended that a long-term strategy to phase out horse trails should be proposed in all national parks in the state.

National park policy makes it clear that recreational opportunities are to be provided for the use and enjoyment of the public. In addition to this there is an increasing lobby for horse-riding opportunities in some natural areas, especially where horse riding has been a traditional activity and land-use patterns have

changed. Prohibiting all horse riding opportunities in national parks may not always be a socially or politically acceptable course of action, as there are issues of equity in the limitation of certain recreational opportunities (Landsberg *et al.*, 2001). Furthermore, the issue of changing land use, for example pastoral land to National Park/protected area and traditional grazing and horse riding, has given rise to conflict and pressure from the horse-riding lobby in Australia.

Despite this, there is now sufficient evidence (Landsberg *et al.*, 2001; Phillips, 2000; Phillips & Newsome, in press, and this paper) to prohibit any new horse-riding activity in national parks and other protected areas. Moreover, the very image that horse-back tourism wishes to convey does not fit with current ideas as to what ecotourism should be. The image of the tough stockman is one of taming the land and clashes with the more sensitive approach of understanding the nature of the Australian environment. The stockman image is not necessarily the appropriate attitude to apply in the conservation estate and actually fits better in more disturbed and agricultural landscapes.

Unrestricted open access

In some areas open access may be considered as part of the horse-riding experience because of a desire to add more excitement or variety to a tour. Areas with a strong horse-riding heritage often fall into this category, such as the southern coast of Western Australia. The work of Phillips (2000) and Phillips and Newsome (in press), however, indicates that with an increasing demand for horse-riding opportunities, given time, the cumulative impacts of free-range riding, horse trails, tethering facilities and campsites, would cause extensive environmental damage. Horse riding also has a high potential to reduce the ecological health of a number of Western Australian national parks by providing the conditions for accelerated erosion, and the transport of exotic plants, *Phytophthora cinnamomi* and other plant diseases.

Given that impacts will be inevitable wherever horse riding occurs, management is required to implement and rigorously enforce a variety of visitor and site-management strategies and techniques capable of controlling impacts. Based on the findings that low levels of horse riding cause a significant degree of vegetation and soil impact, the potential problems of erosion, invasion and spread of weeds and dieback, combined with limited management resources, open access of protected areas for recreational horse riding is inconsistent with conservation objectives and should not be allowed.

Managing tour operators

There are a number of situations, such as places with a history of horse riding, where horse riding will continue to be part of the spectrum of recreational opportunity in a protected area. In Western Australia the current Shannon Park and D'Entrecasteaux National Park Management Plan (CALM, 1987) aims to prohibit open public access, but to authorise a commercial tour operator on a permit basis. This management approach is based on the commercial operator providing for horse-riding opportunities whilst being an accountable body for environmental impacts. The application of a permit provides an incentive for the operator to minimise environmental impacts. The main advantage of providing horse-riding opportunities through a commercial operator is that, theoretically, they have direct control over the number of users and the areal extent of use.

Controlling the areal extent of impact means that potentially severe local impacts only occur in a small proportion of the national park. This leaves most of the park essentially unvisited by horse riders. The advantage commercial operators provide is that they are in a position to enforce very low levels of use, over designated areas within the park. Extent of impact is controlled by confining horse riding to a number of trail systems within the national park. This also helps prevent the transport of *Phytophthora cinnamomi* and exotic plants and weeds.

Because dieback is virtually impossible to eradicate in the field once introduced, elaborate precautions must be taken to minimise the risk of infection (CALM, 1987). Dieback is widespread in a number of national parks. Moreover, there is an urgent need to assess the dieback status within horse-riding areas and to align existing horse trails within uninfected and/or experimentally determined resistant land units. An informed commercial operator can help to confine horse use to low-risk areas, providing management with a tight control on the transport of dieback, whilst providing for horse-riding opportunities.

Commercial horse riding on a permit basis provides an incentive to minimise environmental impacts or face permit suspension or cancellation. This encourages the commercial operators to ensure that all possible precautions are taken to prevent the introduction and transport of exotic plants and weeds, avoid areas of high erosion potential such as coastal dune systems, and use tethering areas with the aim of minimising both the areal and visual extent of impact.

Additionally, it will be necessary to implement an on-going monitoring programme of commercial horse-riding operations in all national parks. Such monitoring should include assessments of baseline conditions and changes in resource conditions over time. Suggested parameters for monitoring are the presence the of *Phytophthora cinnamomi* and other root pathogens, and exotic plants/weeds, permanent quadrats for vegetation parameters, and horse-trail characteristics such as soil and vegetation impact parameters.

The approach described here mirrors that recommended by Landsberg *et al.* (2001) for the Canberra Nature Park. They listed confinement to specified trails, use of trails at the reserve perimeter or on already modified trails, exclusion from areas of conservation significance, and a high degree of rider compliance and monitoring. Given the high potential for horses to degrade trails, a vital component of trail usage is that they are hardened to control weed invasion and erosion and constructed so that adequate drainage is maintained. Landsberg *et al.* (2001) also maintain that if monitoring reveals unacceptable impacts the designated horse riding activity should be reviewed and modified accordingly.

Conclusion

The increase of recreation in natural areas has brought environmental and social impacts. The severity of the recreational impacts appears to be determined by the susceptibility of the environment, as set by environmental factors such as climate, geology, vegetation, soil and topography, combined with use-related factors such as user behaviour and the scale, intensity and frequency of use. Successful management of recreation in national parks, where conservation is a priority objective, requires managers to have a thorough understanding of recre-

ation impacts and the dynamic relationship between environmental and use-related factors that influence these impacts.

The majority of research has shown that horse riding has a high potential to cause environmental degradation at relatively low-use intensities. This is particularly so in the Australian context, where a lack of co-evolution with large herbivores, nutrient-poor soils and introduced soil-borne diseases may magnify these impacts. Even though the severity of the impact depends upon the susceptibility of the environment, high levels of use and consistent horse-riding cause high levels of environmental impact, and intensive horse riding operations in Australian national parks are clearly non-sustainable. These findings emphasise the need for quantitative research that can be used to define the nature of the impact, determine the relative susceptibility of different environments to horse-riding impacts and to create effective management techniques and monitoring systems.

Although horse riding is a popular recreational activity that seeks access to some of the Western Australian national parks and other protected areas, very little research has been devoted to studying the environmental impacts of horse riding at the local level. Such studies are critical to the successful management of recreational areas where horse riding currently takes place, as managers need to understand the nature of impacts and how the severity of impact varies with factors that are subject to management control. The uniqueness and sensitivity of Australia's vast conservation estate demands environmental impact assessments and monitoring of existing horse-riding activities. It is also important to ensure that protected area management decisions are based on quantitative data.

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